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The Influence of Vertical Thermal and Dissolved Oxygen (DO) Trend on Some Fish Species in Oguta Lake, Niger Delta Basin, Nigeria

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Abstract:- Water samples obtained at various depths with the aid of Reuther probe in Oguta lake over a period of one year were analyzed for their thermal and dissolved oxygen contents using digital meters. The results show that the temperature values range from 22 to 28.4^{o}C. The lowest and highest temperature values were obtained at depths of 7.5 and 2.0 m respectively. Generally , the temperature values were observed to decrease with increase in water depth thus indicating a warmer upper layer (epilimnion} and a colder bottom layer (hypolimnion).The investigation also shows that the concentrations of dissolved oxygen range from 3.7 to 7.2 mg/l with he lowest and highest values obtained at 7.5 and 2.0m respectively. The DO concentrations was observed to decrease with increase in water depth and this indicates an anoxic hypolimnion and oxygen-rich epilimnion. The vertical changes in temperature and dissolved oxygen (DO) of Oguta indicates that it is thermally stratified meromictic and eutrophic. The study indicates that the temperature values at depths of 2.0 and 4.0m respectively are favourable for spawning and egg development of Catfish, Buffalo, Thread thin Shad and Gizzard Shad while the values at 6.0 and 7.5m depths are favourable for the growth of migration routes of Salmonis and egg development of Perch. In terms of fish game activity, Carp and Catfish are most active in the epilimnion and are therefore, susceptible to being caught at this upper water layer. However, Largemouth Bass, Spotted Bass and White Bass are susceptible to being caught at the hypolimnion. The concentrations of DO in the hypoliminion indicates slight pollution and this is inimical to survival of aquatic life such as fish.

Keywords:- Epiliminion, hypoliminion, thermal, Reuther probe, meromictic and eutrophic.

I. INTRODUCTION

Oguta lake is the largest natural fresh water resource of non-marine habitant in Imo State, Niger Delta Basin, Southeastern Nigeria. It is located in a low – lying platform (about 50m) precisely within latitudes 5^{0} $41^{/}$ and 5^{0} $44^{/}$ North and longitudes 6^{0} $45^{/}$ and 6^{0} $51^{/}$ East (Fig.1). The Oguta owe its origin from the Late Quaternary Glaciation of the Northern high latitudes which correlate with the Pluvials in the Tropics (Burke et al., 1971)). During the 12,000- 7,000 years of Pluvial period, the Orashi River witnessed incised meandering that continued to swell out into broad loop with gradual narrowing of its neck that was later cut off into big ox-bow lake (Oguta lake). The present linear shape of the lake which masks the bow shape may be due to active erosion at the Njaba River end. Photo geological observation and interpretation reveals the presence of ox-bow lake in Oguta area. The surface area of the lake during the dry and wet seasons are 1.8and 2.5km^2 while the maximum depth of the lake is 8.0m. The lake has a mean depth and shoreline length of 5.5m and 10km respectively (Odigi and Nwadiaro,1988). The annual water storage of the lake is about 16, 185,S00m^3 while the portion currently covered by eutrophication is about 5% of the total area of the lake (Ahiarakwem et al., 2012). Lozan consultants (1976) investigated the possible use of the lake as a port while the chemical hydrology of the lake was studied by Nwadiaro and Umeham (i985). The vertical variations of some chemical parameters in the lake was studied by Ahiarakwem, 2011). However, the implications of the vertical thermal and dissolved(DO) trend on auatic life such as fish and associated biota is yet to be investigated. The decline in the fishing activity in the lake calls for constant monitoring of basic parameters that affects sustainable fisheries development.

Oguta lake is of immense benefit to both the local community and environs as well as the Imo State Government of Nigeria. To the former, it serves as the main source of domestic water supply in addition to its use for transportation, for recreation, fishing and sand mining activities. To the later, it constitute a focal point for research. tourism and sports development. The physical and bio-chemical character of the lake is constantly being modified by human and natural activities within and round it and this is capable of altering its resource status and usefulness. One approach to maintain the resource status and usefulness of the lake is regular monitoring of the chemistry of both the epilimnion and hypolmnion portions of the lake.

II. CLIMATE AND VEGETATION

The study area is located within the equatorial rain forest belt of Nigeria. The mean monthly temperature of the area ranged from 25 to 28.4 ^{o} C while the mean annual rainfall is about 3.000 mm. Most of the rainfall is recorded between the months of May and October (National Root Crop Research Institute' 2012). The rainy period (May-October) is marked by moderate temperature and high relative humidity. The months of November to April have scanty rainfall, higher of temperatures and low relative humidity (NationalRoot Crop Research Institute, 2012). The wind direction in Oguta area is mainly South-West, North-West and West. However, the South-West wind direction is the strongest (Anyanwu and Oueke. 2003). The vegetation cover include shrubs and economic trees such as oil palm (arecaceae), Indian bamboo (bambusae), avocado pea (*Persia Americana*),African bread fruit (*Trelulia Africana*), oil bean (*pentaclethra mahophlla*) and raffia palms (*raphia ruffia*). Due to relatively steep shoreline and significant water current, aquatic *macrophytes*, especially the floating and rooted submerged vegetation are sparse. Most parts of the 10km shoreline are lined up by a community of bank *macrophytes* consisting of grasses such as P*anicum sengalense.* The Orashi River end consists of sparse population of floating *macrophtes* such as *Pistia stratiotes, Azollia Africana, Salvinnia auriculata,Ceraphyllum demersum Ulyiculariainflexa* and water lilies- *Nymphyaea lotus, N.Macrantha* plant life is poor and restricted to the littoral zone (<1.5m depth). This consists of *Crinum natan* and some unidentified grass with very fine leaves (Odig andNwadiaro, 1988)

III. GEOLOGICAL SETTING AND HYDROLOGY

The study area (Fig.2) is located within the Niger Delta basin of Nigeria which consists of three major lithostratigraphic units namely Benin. Agbada and Akaa Formations).The modern Niger delta started its growth after the Paleocene transgression which was followed by a cycle of deposition in the Eocene and continued till the present day (Hospas, 1965). The local geological setting of Oguta lake indicates that it falls within the Benin Formation which consists of friable sands , shale/clay lenses , isolated units of gravels, connglomerates and very coarse sandstones (Ananaba et al., 1993). It is Pliocene to Miocene in age with a mean thickness of about 800m around the study area (Avbovbo, 1978).The surface geology of the Oguta area indicates that it is characterized by ferruginized sands that are occasionally pebbly and massively bedded (Odigi and Nwadiaro, 1988).

Four rivers are associated with the Oguta lake freshwater resource. Two of the rivers (Njaba and Awbana) flows into the lake while the third (Orashi) flows past the lake at its southwestern end (Fig.1). A fourth associated river (Utu) flows into the lake only during the wet season. About 87.6% of total annual water inflow into theOguta lake comes from channel inflow from Rivers Njaba, Utu and Awbana (Ahiarakwem et al., 2012). Other water inflow sources are groundwater and rainfall or precipitation. The lake is adequately recharged all the year round. Apart from these rivers, there is also input from precipitation (rainfall).

IV. MATERIALS AND METHODS

The sampling period covered the two hydrological regimes of the year, the dry and wet seasons. Sampling was conducted on a bi-monthly basis commencing from January, 2012 and ending in November, 2012. The water samples were obtained with the aid of sterilized 2-litres plastic bottles at depth intervals of 2.0, 4.0, 6.0 and 7.5metres using the Reuther Probe. The sampling point (Db), locally known as Ogbe Hausa represents

The deepest part of Oguta lake (depth;8.0m) Fig.1. The dissolved oxygen (DO) of the water samples were determined using digital DO probe while the temperature was determined using mercury in glass thermometer (range: 0-100^{0}C).

V. RESULTS AND DISCUSSION

The results of the monthly concentrations of the temperature and dissolved oxygen (DO) at various depths is summarized in Table 1.

5.1 Thermal Trend

The temperature varies from 24 to 28.4^{o}C at 2.0m depth (Table1 andFig.3a) and from 24 to 27.5^{o}C at 4.0m depth (Table 1 and Fig.3b). The range of temperature at the depth of 6.0m is 24 to 26.5^{o}C (Table and Fig.3c) while the range at 7.5m is 22 to 24.5^{o}C (Table1and Fig.3d). The highest temperature (28.4^{o}C) was recorded in January at the depth of 2.0m while the lowest (22^{o}C) was recorded in November at the depth of 7.5m. The monthly temperature values are higher during the dry season than in the rainy season; this is precisely the case at depth range of of 2.0- 4.0m (Figs.3a and 3b)) representing the epiliminion (Fig.4). However at the hypoliminion (Fig.4) represented by depth range of 6.0- 7.5m (Figs.3c and 3d) , the seasonal factor becomes irrelevant. The mean temperature values at various depths shows a general decrease with increase in depth (Table 1and Fig.4). This is because of the relatively higher warming up of the epilimnion than the hypolimnion by solar radiation. The vertical temperature change segments the lake into a warmer upper layer (epilimnion) and a lower layer (hypolimnion) which is cooler. These two segments are separated by a point of inflexion (thermocline or metalimnion). This two – layer temperature structure is typical of tropical lakes (Nwadiaro and Umeham, 985).

The temperature values for the month of July were observed to be almost isothermal (Fig.3b); this is consistent with Turekian (1972) findings that isothermal conditions exists in surface waters at the peak of rainy seasons resulting in lack of significant vertical thermal changes. However, this is subject to climate change phenomenon. Verticalthermal changes has impact on sustainable fisheries development (Mccauly and Crossland, 1974). Some fish species and associated biota are favoured by high temperature while others are favoured by low temperature. Based on vertical thermal trend of Oguta lake, the epilimnion (2.0- 4.m depth) is favourable for growth of Pike, Perch, Walleye, Smallmouth Bass and Suager while the hypolimnion (6.0- 7.5m) is favourable for spawning and egg development of Catfish, Buffalo, Thread Thin Shad and Gizzard Shad (Table 2). If the temperature of the hypolimnion drops to 20^{o}C probably due to climate change, the hypolimnion would become favourable for growth of migration route of Salmonis , egg development of Perch and Smallmouth Bass (Table2). A sudden change in temperature values can result in loss of certain fish species and biota (Mccauly and Crossland, 1974). This calls for a well programmed regular monitoring of thermal trend of our surface resources. In terms of fish game activity, all fish species have preferred temperature range in which they are most active and therefore susceptible to being caught (Table 3). Carp and Catfish are most active at temperatures of 29 and 28^{o}C respectively (Table 3) and are thus likely to be easily caught at the epilimnion of Oguta lake. However, Largemouth Bass, Spotted Bass and White Bass which are most active at water temperatures of 21, 24 and 21^{o}C would be easily caught at the hypolimnion. If the temperature of the hypolimnion drops to 19^{0}C, it would favour easy catching of Smallmouth Bass, Sunfish, Walleye and Chain Pickerel (Table 3).

5.2 Dissolved Oxygen (DO)

The concentrations of DO generally range from 3.70 to 7.20mg/l (Table1). The concentrations of DO at 2.0m varies from 6.20 to 7.20mg/l (Table1 and 5a) while the range at 4.0m is 5.0- 6.0mg/l (Table 1 and Fig.5b) . DO concentrations range from 4.4 to 54mg/l at 6.0mwater depth (Table 1 and Fig.5c) while at 7.5m depth, it varies from 3.7 to 5.0mg/l (Table 1 and Fig. 5d)). The highest (7.2 mg/l) DO concentration was obtained at the depth of 2.0m while the lowest (3.70mg/l) was obtained at the depth of 7.50m (Table 1). This indicates an oxygen-rich epilimnion respectively at the depth of 2.0m and an anoxic hypolimnion. The mean concentrations of DO at various depths decreases with increase in water depth (Table 1 and Fig.6). Redox reactions in lakes are usually determined by the balance between the decomposition of organic matter normally from photosynthesis in the lake and the supply of oxygen by circulation or vertical mixig of water (Drever, 1997). In lakes, some decomposition takes place in the epilimnin but it is in the hypolimnion that its effects really becomes apparent. Near the surface of lake, any oxygen used for decomposition of organic matter can be replaced by photosynthetic activity of other planktonic or by the input of oxygen from the atmosphere (Maskers, 1974). In the hyolimnion, neither of these processes is possible and one expect to find the dissolved concentrations lower than those predicted by the simple physical reasoning (Rainswell, et al. 1992}. When plankton (with a short life cycle of approximately 3 weeks) dies, they sink to the bottom of the lake (hypolimnion) and become decomposed by aerobic metabolism resulting in the reversal of the photosynthetic reaction at the bottom of the lake. The decomposition of organic matter (Phytoplankton) at the bottom of the lake results in the consumption of oxygen as well as the release of nutrients to the water (Visser, 1974). The above explanation accounts for the oxygen-rich epilimnin and anoxic hypolimnion. The anoxic nature of the hypolimnion especially at 7.50m is inimical to the survival of aquatic life such as fish. The mean concentration of DO at 7.50m was 4.4mgl. according to Prat et al., 1970, surface water with DO of 7.8 and 6.2mg/l are classified as excellent and acceptable respectively while those with DO concentrations of 4.6 and 1.8mg/l are classified as slightly polluted and polluted respectively. Surface water with DO concentration of less than 1.8mg/l is considered to be heavily polluted (Table 4). Based on this classification, the hypolimінion of Oguta lake is slightly polluted while the epilimnion is not polluted. The epilimnion according to Prat et al., 19 classification of surface water quality falls within excellent and acceptable levels. This presupposes that the epilmnion is more favourable for sustainable fisheries development than the anoxic hypolimnion.

The vertical thermal and dissolved oxygen(DO) trend in Oguta lakes indicates that it is meromictic. Meromictic lakes has layers of water that do not intermix. In ordinary olomictic lakes, at least once each year, there is a physical mixing of the surface (epilimnion) and deep waters (hypolimnion). This mixing can be driven by wind which creates waves and turbulence at the kake,s surface. This can result in vertical mixing the warmer surcace and deep waters sometimes creating an isothermal condition. In Oguta lake, the,the wind stress energy range from 0.20 to 0.41g/cm/sec^{2} (Ahiarakwem,2012). This wind stress energy is considered low and as such cannot cause strong vertical mixing of surface and deep waters hence the lake is meromictic. Meromictic lakes such as Oguta, green lake in Newyork and lac Du Bouget which is the largest lake in France among other uses are usually excellent for sustainable tourism, fisheries and transport development.

VI. CONCLUSION

The oguta lake is segmented into an upper layer (epilimnion) and a lower or ottom layer (hypolimnion) based on clinograde resulting from vertical thernmal and dissolved oxygen (DO). The vertical thermal variations shows that the lake is eutrophic and thermally stratified. The thermaland dissolved oxygen concentrations generally decreases with increase in water depth. The eplimnion is favourable for growth of Pike,Perch, Walleye, Smallmouth Bass and Saugar while the hypolimnion is favouable for spawning and development of Catfish, Buffalo,, Thread Thin Shad and Gizzard Shad. Carp and Catfish are susceptible to being easily caught at the epilimnion while Largemouth Bass, Spotted Bass and White Bass are most active at the hypoliminion and therefore would be easily caught there. The investigation also shows that the epilimnion is not polluted while the hypolimnion is slightly polluted. Based on the vertical thermal and dissolved oxygen (DO) trends, the epilimnion is more favourable for survival of aquatic life such as fish and associated biota than the anoxic hypolmnion.

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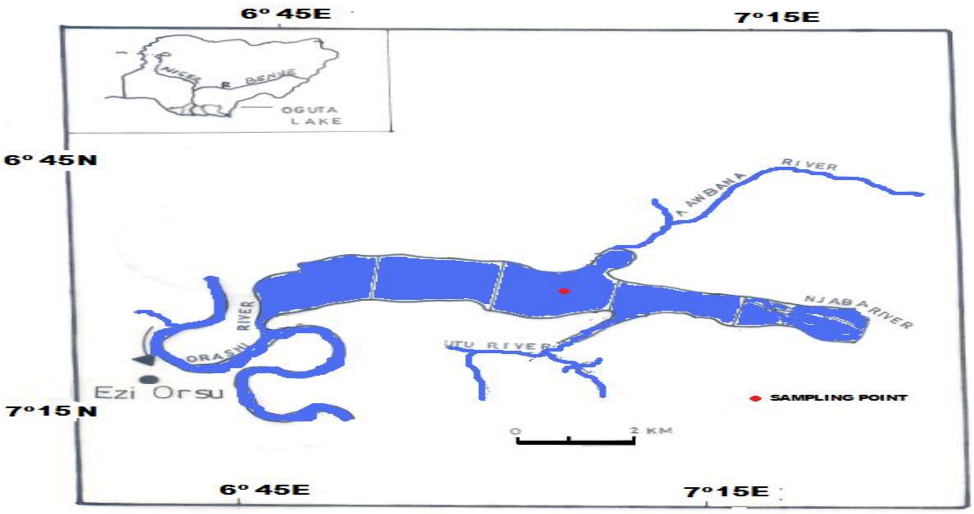

Figure 1. Map of the study area showing sampling location

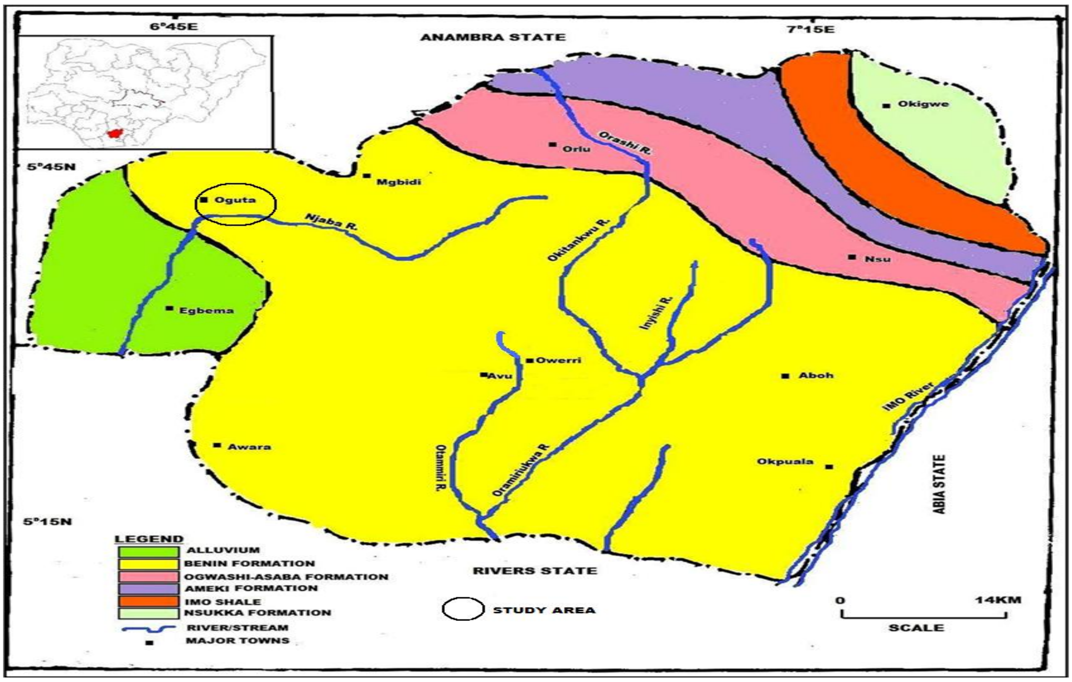

Figure 2. Geological map of Imo State showing the study area

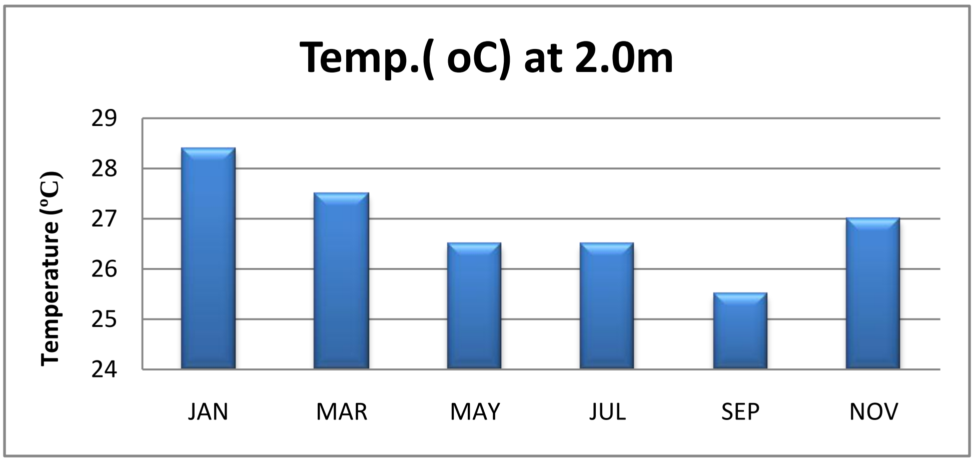

Figure 3a. Monthly variations of temperature at 2.0m depth

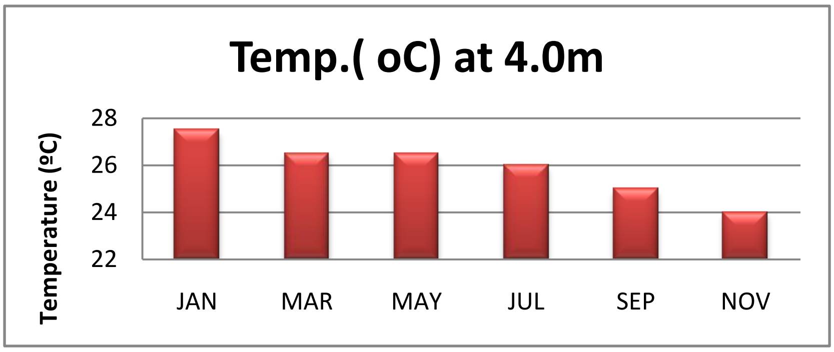

Figure 3b. Monthly variations of temperature at 4.0m depth

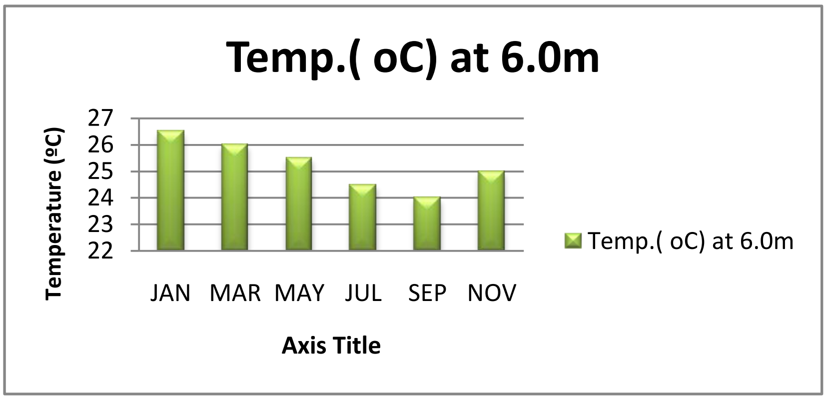

Figure 3c. Monthly variations of temperature at 6.0m depth

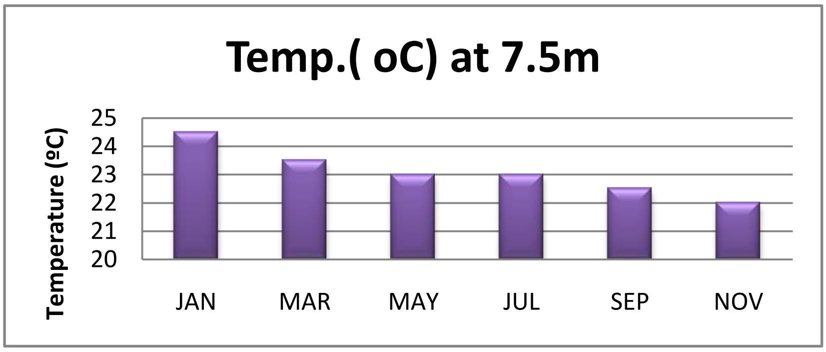

Figure 3d. Monthly variations of temperature at 7.5m depth

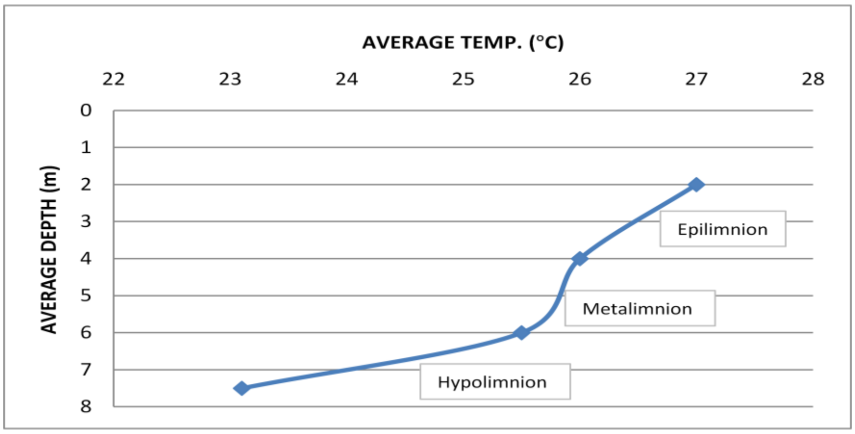

Figure 4. Variations of mean monthly temperature with depth

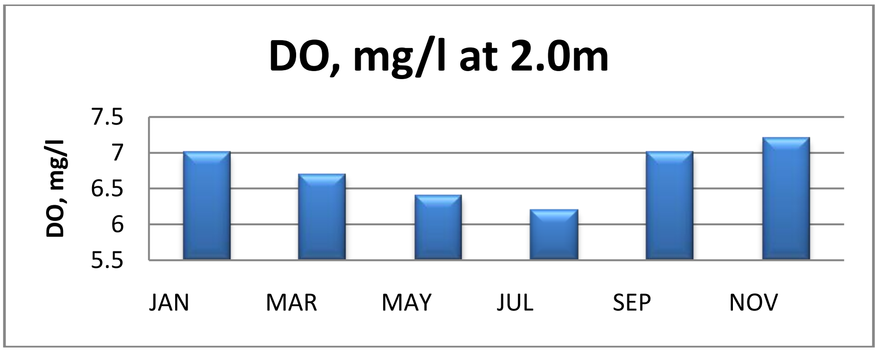

Figure 5a. Monthly variations of dissolved oxygen (DO)at 2.0m depth

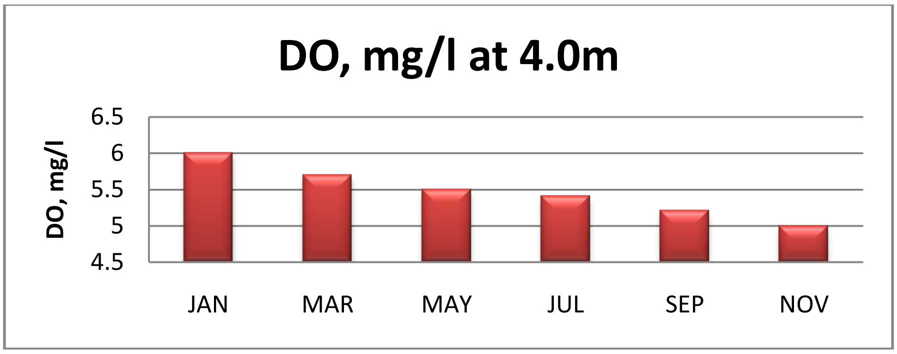

Figure 5b. Monthly variations of dissolved oxygen (DO)at 4.0m depth

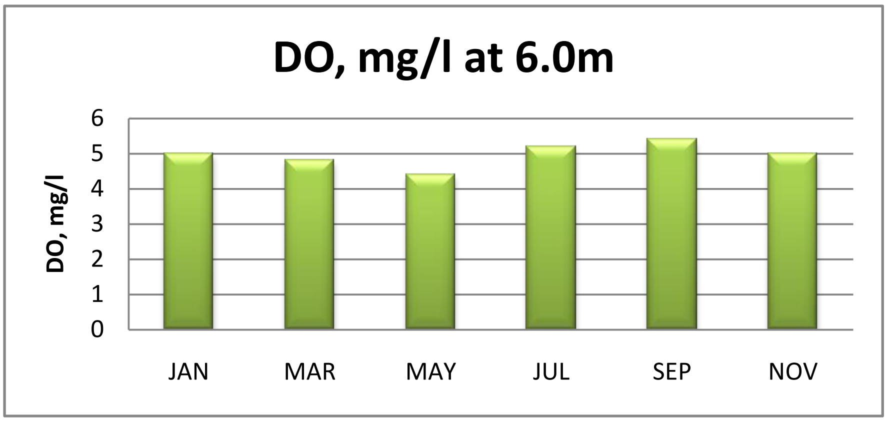

Figure 5c. Monthly variations of dissolved oxygen (DO)at 6.0m depth

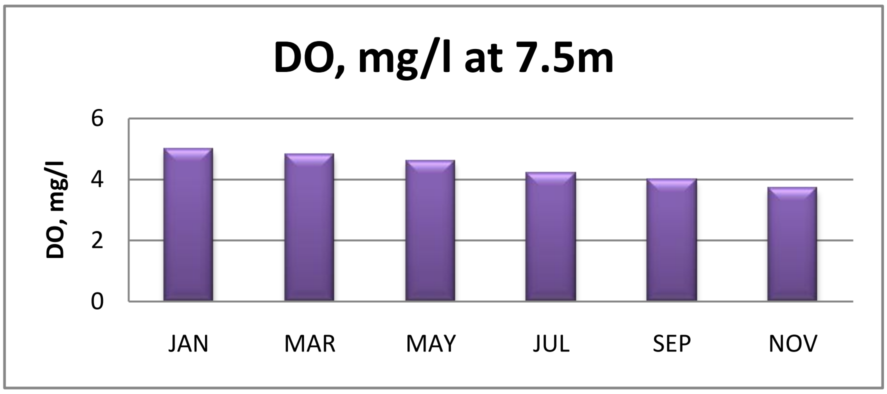

Figure 5d. Monthly variations of dissolved oxygen (DO)at 6.0m depth

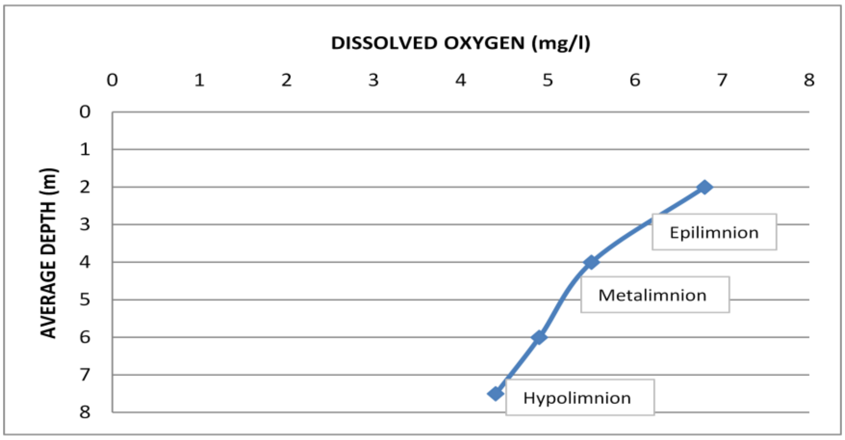

Figure 6. Variations of mean dissolved oxygen with depth

Table 1. Vertical variations of temperature and dissolved oxygen (DO) of Oguta lake

DEPTH	2.0m							4.0m						
PARAMETER	JAN	MAR	MAY	JUL	SEP	NOV	AV	JAN	MAR	MAY	JUL	SEP	NOV	AV
Temp.(°C)	28.4	27.5	26.5	26.5	25.5	27	27	27.5	26.5	26.5	26	25	24	26
DO, mg/l	7.0	6.7	6.4	6.2	7.0	7.2	6.8	6.0	5.7	5.5	5.4	..5..2	5.0	5.5

DE\PTH	6.0m							7.5m						
PAR\\\AMETR	JAN	MAR	MAY	JUL	SEP	NOV	AV	JAN	MAR	MAY	JUL	SEP	NOV	AV
Temp.(°C)	26.5	26.0	25.5	24.5	24	25	25.5	24.5	23.5	23.0	23	22.5	22	23.1
DO, mg/l	5.0	4.8	4.4	5.2	5.4	5.0	4.9	5.0	4.8	4.6	4.2	4.0	3.7	4.4

Table 2. Maximum recommended temperatures for various fish species and their associated biota

TEMPERATURE (^{O}C)	Species and Biota
33.9	Growth of Catfish,Gar- white or yellow Bass, Spotted Bass, Buffalo, Thread Thin Shad and GIzzard Shad
32.0	Growth of Largemouth Bass Drum, Blue gill and Crappie
28.9	Growth of Pike, Perch Walleye, Smallmouth Bass and Sauger
26.7	Spawning and egg development of Catfish, Buffalo, Thread Thin Shad and Gizzard Shad
20.0	Growth of migration route of Salmonis, egg development of Perch and Small mouth Bass
12.8	Spawning and egg development of Salmonils and Trout
8.9	Spawning and eeg development of Lake Trout, Walleye, Northern Pike/Sauger and Atlantic Salmon

Source: Mccaully Crossland, i974

Table 3. Ideal water temperatures for most popular species of freshwater fish.

TEMPERATURE (^oC)

FISH SPECIES	LOWER	MOSTACTIVE	UPPER
Black Crappie	15	21	24
Bluegill	14	20	24
BrookTrout	7	14	21
Brown Trout	7	14	23
Carp	24	29	31
Chain Pickerel	5	19	23
Catfish	13	28	32
Chinook Salmon	7	12	15
Coho Salmon	7	12	15
Green Sunfish	23	31	33
KamploopsTrput		9	14
Lake Trout	4	12	17
Lake Whitefish	6	11	17
Largemouth Bass	10	21	29
Northern Pike	13	17	23
Rainbow Trout	7	16	24
Sauger	13	19	23
Smallmouth Bass	16	19	23
Spotted Bass	22	24	27
Steelhead Trout	3	10	16
Sunfish	10	19	20
Walleye	10	19	24
White Bass	17	21	26

Source: Outdoorlife(2012)

Note: Plus or minus 3 degrees of "
Most Active" water temperatures is prime fishing.

Table 4. Prat et al., classification of surface water quality

PRAMETERS	EXCELLENT	ACCEPTABLE	SLIGHTLY POLLUTED	POLLUTED	HEAVILY POLLUTED
pH	6.5- 8.0	6.0- 8.4	5.0- 9.0	3.9- 10.1	<3.9
BOD, mg/l	1.5	3.0	6.0	12.0	>12.0
DO,mg/l	7.8	6.2	4.6	1.8	<1.8
COD,mg/l	10	20	40	80	>80